

Title: **Examining Treatments Used on Colorado Spruce to Maintain Postharvest Quality**

Principal Investigators: **Robert R. Tripepi and John E. Lloyd  
University of Idaho**

Date: **January 5, 2004**

Report Series: **Final Report, September through December 2003**

Grant Agency & Amount: **NAC/ISDA 2003-3, \$21,366**

## FINAL STATUS OF THE PROJECT

### Experimental Technique:

This experiment involved using fertilizer treatments on 5 to 6 ft tall balled and burlapped trees of Colorado spruce while they were being held in a mulch bed. The study started with the trees being received on April 28, 2003. Sixty of the most uniform trees were selected out of the 66 trees received. Extra trees were used as a guard row. All root balls on the trees were 24 inches in diameter. The trees were evaluated over the next three weeks, and those chosen for the experiment were randomly assigned to one of five treatments in one of four blocks. The mulch bed was 30 feet by 94 feet. Fertilizer treatments, except for the compost treatment, were applied on June 2, to begin the experiment. The fertilizer treatments included a control (pine bark without fertilizer), Osmocote 15-9-12 distributed over the top of the ball at 114.2 grams (label rate) per root ball, Ross® Gro-Stakes® 10-10-10 Evergreen fertilizer spikes, one-half cartridge of Ross Root Feeder® 10-12-12 evergreen fertilizer injected into the root ball at four points, and a 50:50 mixture (by volume) of Eko Compost mixed with pine bark. The compost mixture was applied to the root system on May 29 and 30. Pine bark mulch covered the bottom and sides of



Figure 1. Colorado spruce trees in the process of being heeled into a 30 ft. by 94 ft. bed. The root balls are on top of Typar® landscape mat and surrounded by fresh pine bark mulch.

the root balls, but the tops were left uncovered (Figure 1) to prevent watering problems. Plants were watered by hand and overhead sprinklers until a spray stake irrigation system was completed by June 30.

Different measurements and samples were taken during the experiment. On May 28, initial tree heights and trunk diameters (at 20 cm above the root ball) were measured. Foliar (needle) samples were also taken on May 28. When foliar samples were taken, about three inches of stems from three branches (newest growth on each sampling date) were removed from each tree and dried in a drying oven at 70°C for three days. After drying, needles were removed from the stems and ground before being sent for foliar mineral analyses. A second set of foliar samples were taken from the trees on July 28, about the halfway point of the experiment. The experiment ended on September 29. On this date, final foliar samples were taken. In addition, final tree heights and trunk diameters were measured. Soil samples were taken on May, 28, July 28, and September 29. These samples were taken from each root ball so that soil nitrogen (ammonium and nitrate) levels could be determined. The effects of the fertilizer treatments on changes in tree height and trunk diameter by the end of the growing season, on foliar nutrient levels and their changes by the end of the growing season, and on concentrations of ammonium, nitrate, and total mineral nitrogen in the soils were analyzed by analysis of variance. Significant differences between treatment means were determined by Least-Square Means at the 5% level if analysis of variance indicated a significant treatment effect. Means and standard deviations for concentrations of soil nitrogen were also determined.

### **Results and Discussion:**

Overall, the Colorado spruce trees appeared quite normal throughout the study. Foliar color of all trees appeared similar regardless of the fertilizer treatment used, even though foliar nutrition varied among the trees (see below). The spruce trees tolerated the very hot July and August weather well. During late July, some needles on a few trees turned purple, indicating water stress, but the trees suffered minimal stress, and all appeared healthy in the experiment. We were able to minimize the heat and drought stress of the spruce trees by using spray stakes for the irrigation system and cyclic application of water. The trees were watered three times a week using cyclic irrigation to be sure the water was able to be absorbed by the root balls. Root balls usually received two and sometimes three cycles of water (15 minutes of water per cycle and 7.9 gallons per day of irrigation) on days that the trees were irrigated.

Changes in tree height and trunk diameter by the end of the growing season (as determined by percentages of change from initial measurements) were unaffected by the fertilizer treatments applied to the root balls in June (Table 1). Likewise, final tree heights and trunk diameters were similar regardless of the fertilizer treatment used (data not shown). Apparently, the fertilizer treatments had little effect on the tree growth over the summer. Most likely the trees were strongly influenced by transplant shock and so they grew only a minimal amount despite being fertilized (compare the changes in growth – heights and diameters – of control {without fertilizer} versus fertilized plants). Therefore, the fertilizer treatments failed to improve tree growth during the first growing season after digging.

These results are interesting for several reasons. First, the fertilizer treatments failed to affect final tree heights and trunk diameters and changes in these growth parameters in two separate

studies with Colorado spruce trees from different nurseries. Therefore, transplant shock apparently limited postharvest growth of these trees, regardless of the fertilizer treatment applied. Second, the weather was different both years, and spruce trees in the 2002 experiment were water stressed due to several reasons, including an inadequate irrigation system. The trees in the 2003 experiment suffered very little water stress due to a better irrigation system and improved management. Despite the differences of drought stress and different weather, height growth and trunk diameter increases of the Colorado spruce trees failed to be affected by the fertilizer treatments both years. This reinforces the suggestion made in last year's final report. In that report, I (Tripepi) suggested that transplant shock was so strong that it determined how much the trees would grow, regardless of the postharvest fertilizer treatment they received, and now apparently how much they were drought stressed over the summer. The bottom line is that digging 5 to 6 foot tall Colorado spruce trees stresses them severely, and they will grow only a small amount the year immediately after digging. Perhaps root pruning or some other nursery cultural practice could better prepare the trees for digging and reduce the severity of transplant stress, which would enable the trees to grow more the first season after digging.

Table 1. Percentage changes in tree heights and trunk diameters as affected by fertilizer treatments applied to the root balls of Colorado spruce trees. Trunk diameters were measure at 20 inches (51 cm) above the root ball. Initial measurements were made in May and final measurements in September.

Treatment	Change in tree height <sup>z</sup> (%)	Change in trunk diameter <sup>y</sup> (%)
Bark control	5.5	4.5
Osmocote 15-9-12	7.1	7.0
Fertilizer spike 10-10-10	5.2	5.0
Injected fertilizer 10-12-12	6.1	5.5
50:50 Compost:bark mix	5.8	6.7

<sup>z</sup> Change in tree height was calculated by comparing the change in height over the growing season divided by the initial height:  $\text{height change} = (\text{final hgt.} - \text{initial hgt.}) / \text{initial hgt.}$

<sup>y</sup> Change in tree diameter was calculated by comparing the change in diameter over the growing season divided by the initial diameter:  $\text{diameter change} = (\text{final diam.} - \text{initial diam.}) / \text{initial diam.}$

The foliar nutrition of the Colorado spruce trees was affected by the fertilizer treatments (Tables 2, 3, and 4). The initial (spring) foliar mineral levels were similar for all trees before fertilizer treatments were applied (Tables 2 and 3). The fertilizer treatments affected mineral nutrition of foliar N, Mg, Ca, S, Mn, and B by fall (Tables 2 and 3). By fall, needles from trees treated with the mixture of 50:50 compost:bark had the highest levels of these six minerals. Trees treated with one tree spike had the second highest levels of foliar N, and these levels were significantly higher than those of trees receiving the other fertilizer treatments. When comparing the 2002 foliar nutrition data against the 2003 foliar data, the trends were very similar, but Mn

foliar levels were significantly affected by fertilizer treatments only in 2003. In 2002, needles from compost-treated spruce trees analyzed in fall had the highest levels of foliar N, but levels were statistically similar to those levels from trees receiving the spike and injection fertilizer treatments (refer to last year's report). Based on these data, the compost mixture and fertilizer spike appeared to supply the Colorado spruce trees with the most N and S, with the compost being the most effective in supplying these minerals.

Table 2. Percentages of minerals in needles from Colorado spruce trees treated with different fertilizers. Foliar samples were taken in late May (spring) or late September (fall). Data within a column followed by a different letter are significantly different at the 5% level.

Treatment	%N		%P		%K		%Mg		%Ca		%S	
	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall
Pine bark	1.0	1.2 c	0.1	0.2	0.4	0.6	0.06	0.08 b	0.46	0.16 b	0.06	0.07 c
Compost	1.0	1.8 a	0.1	0.3	0.4	0.7	0.06	0.13 a	0.44	0.40 a	0.06	0.11 a
Osmocote	1.0	1.3 c	0.1	0.2	0.3	0.6	0.06	0.08 b	0.46	0.17 b	0.06	0.07 c
Injection	1.0	1.2 c	0.1	0.2	0.3	0.7	0.07	0.08 b	0.51	0.16 b	0.06	0.07 c
Spike	1.1	1.6 b	0.1	0.2	0.4	0.6	0.06	0.09 b	0.43	0.21 b	0.06	0.09 b

Table 3. Parts per million of minerals in needles from Colorado spruce trees treated with different fertilizers. Foliar samples were taken in late May (spring) or late September (fall). Data within a column followed by a different letter are significantly different at the 5% level.

Treatment	Fe (ppm)		Mn (ppm)		B (ppm)		Cu (ppm)		Zn (ppm)	
	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall
Pine bark	57	132	89	81 b	8.5	11 b	1.4	2.2	20	14
Compost	57	150	94	198 a	9.2	17 a	1.5	2.1	20	17
Osmocote	57	144	96	94 b	8.1	10 b	1.7	1.8	20	16
Injection	60	130	101	97 b	8.2	9 b	1.3	1.3	20	17
Spike	62	131	87	116 b	7.9	10 b	1.3	1.8	22	17

Only Mg, Ca, and S levels in the spruce tree needles were affected by the fertilizer treatments for the late July sampling date (data not shown). Needles on trees treated with compost or the fertilizer spike had similar levels of these three nutrients, but their concentrations were higher than those in needles receiving any of the other three treatments (Osmocote®, fertilizer injection, or bark control). Although the levels of these three nutrients were statistically different (higher) for compost and spike treated trees, the concentrations were close for trees receiving the other treatments, indicating that the different concentrations were of little biological significance.

Differences between initial and final foliar nutrient levels were also examined to determine if the fertilizer treatments affected the changes over the growing season. The fertilizer treatments effected changes for six nutrients in the Colorado spruce needles (Table 4). Needles from trees receiving the compost treatment had the highest changes for N and S concentrations followed by needles from trees receiving the fertilizer spike treatment. The compost treatment also resulted in the highest changes of Mg, Ca, Mn, and B within the tree needles. The negative numbers for percentage Ca and Mn changes mean that the concentrations of these two minerals in the needles at the end of the season were lower than they were at the beginning of the growing season (Table 4). Even so, needles from compost treated trees had the least amount of negative change for Ca, indicating Ca levels after one season in the mulch bed were closer to those levels in needles at the start of the experiment. The doubling (~124%) of the Mn concentrations in needles on trees treated with compost showed that Colorado spruce tree can take up large quantities of this mineral if it is available to the roots (Table 4).

Table 4. Percentage changes in nutrient level of Colorado spruce needles treated with different fertilizers. Differences were determined for nutrient levels in foliar samples taken in late May and again in late September. Data within a column followed by a different letter are significantly different at the 5% level.

Treatment	% Change N	% Change Mg	% Change Ca	% Change S	% Change Mn	% Change B
Pine bark	17 c	31 b	- 64 b	14 b	- 4 b	34 b
Compost	80 a	99 a	- 3 a	95 a	124 a	98 a
Osmocote	22 c	31 b	- 62 b	26 b	2 b	25 b
Injection	17 c	28 b	- 66 b	20 b	9 b	11 b
Spike	50 b	55 b	- 50 b	70 a	38 b	30 b

Levels of six foliar nutrients (N, P, K, Mg, Fe, and B) increased by the end the growing season whereas one, Ca, decreased by the end of September, regardless of the fertilizer treatment used (Tables 2 and 3). These overall foliar concentrations in late May versus late September were not compared statistically, but they are of interest. For instance, N levels increased in needles from trees receiving compost or the fertilizer spike, yet trees receiving the other treatments still had needles with higher N levels than when the needles were taken in spring. The levels of P, K, Mg, Fe, and B in the needles seemed to increase, regardless of the fertilizer treatment used. In contrast, the concentration of Ca and Zn in needles decreased regardless of the treatments used. We speculate that the increases indicate that the bark mulch supplied some minerals that were less available to the trees in the soil. On the other hand, the bark mulch lacked certain minerals and so these levels were lower in the needles by the end of the growing season. Only the reduced levels of Ca in the needles seemed to be near mineral deficient levels. Increases or decreases of foliar minerals over the growing season may be part of the normal fluctuation of minerals during the year. Additional experiments would be needed to verify if the bark supplied certain nutrients or if the mineral levels in the needles fluctuated naturally over the growing season.

The mineral nitrogen content of soil in the root balls appeared to be unaffected by the fertilizer treatments with the exception of soil nitrate levels during July (Tables 5 and 6). Analysis of variance indicated that fertilizer treatments affected nitrate and total mineral N levels in the soil only for the July sample date (data not shown). Total mineral N is the sum of ammonium and nitrate in the sample, but only nitrate was significant only in the July analyses. Therefore, nitrate concentrations seemed to be affected by the fertilizer treatments during July. The standard deviations, however, were quite large for the higher nitrate values, so the significance of this result is uncertain. The data also indicated that the nitrogen content changed with the season, with ammonium and nitrate concentrations usually being highest during the July but low in May and at a moderate level in September (Tables 5 and 6). The peak in soil nitrate concentrations in late summer was similar to results obtained in the 2002 study (refer to last year's report).

Table 5. Ammonium and nitrate content of soil in root balls of Colorado spruce trees as affected by fertilizer treatments used. The roots balls were sampled three times (May, July, and September) during the growing season. Data are means  $\pm$  their standard deviations.

Treatment	May-NH <sub>4</sub> (ppm)	July-NH <sub>4</sub> (ppm)	Sept.-NH <sub>4</sub> (ppm)	May-NO <sub>3</sub> (ppm)	July-NO <sub>3</sub> (ppm)	Sept.-NO <sub>3</sub> (ppm)
Pine bark	1.6 $\pm$ 1.1	1.2 $\pm$ 0.6	1.8 $\pm$ 1.2	6.2 $\pm$ 5.7	4.7 $\pm$ 3.3	9.7 $\pm$ 11.4
Compost	2.2 $\pm$ 3.0	5.4 $\pm$ 9.4	1.0 $\pm$ 0.4	3.1 $\pm$ 2.9	21.6 $\pm$ 18.3	4.8 $\pm$ 11.9
Osmocote	2.0 $\pm$ 1.6	2.6 $\pm$ 3.1	7.1 $\pm$ 13.5	6.3 $\pm$ 6.4	23.0 $\pm$ 21.8	11.5 $\pm$ 19.2
Injection	1.6 $\pm$ 1.0	1.7 $\pm$ 2.2	2.6 $\pm$ 2.1	3.2 $\pm$ 3.4	4.9 $\pm$ 4.4	15.0 $\pm$ 14.7
Spike	1.3 $\pm$ 1.1	1.1 $\pm$ 0.5	6.4 $\pm$ 11.2	6.0 $\pm$ 4.6	7.2 $\pm$ 4.3	25.1 $\pm$ 28.0

Table 6. Total mineral nitrogen content of soil (the sum ammonium and nitrate levels) in root balls of Colorado spruce trees as affected by fertilizer treatments used. The roots balls were sampled three times (May, July, and September) during the growing season. Data are means  $\pm$  their standard deviations.

Treatment	May-Min. N (ppm)	July-Min. N (ppm)	Sept.-Min. N (ppm)
Pine bark	7.8 $\pm$ 6.3	5.9 $\pm$ 3.5	11.6 $\pm$ 12.4
Compost	5.3 $\pm$ 3.5	27.0 $\pm$ 26.3	5.7 $\pm$ 12.2
Osmocote	8.3 $\pm$ 6.8	25.6 $\pm$ 23.7	13.6 $\pm$ 21.0
Injection	4.8 $\pm$ 3.3	17.6 $\pm$ 16.3	17.6 $\pm$ 16.2
Spike	7.3 $\pm$ 4.7	8.3 $\pm$ 4.4	31.5 $\pm$ 39.0

Repeating the experiment a second year provided several important insights into how 5 to 6 foot tall Colorado spruce trees responded to being harvested. First, during the 2002 and 2003 studies, balling and burlapping the trees most likely caused enough stress or shock to them that the trees increased only a limited amount in plant height or trunk diameter during the first

growing season after digging, regardless of the fertilizer treatment used (Table 1). Even though increases in plant heights and diameters were similar, foliar nutrition of the trees varied according to the fertilizer treatments used. In the 2002 and 2003 experiments, foliar N, Mg, Ca, S, and B were significantly higher in needles from compost-treated trees compared to needles from trees receiving the other treatments (Tables 2 and 3). The fertilizer treatments affected significant changes in foliar mineral levels for N, S, and Mn during 2002 and 2003. In addition, the trends for fertilizer effects on changes in foliar Mg and B levels in spruce trees during 2002 were statistically significant in the 2003 study (Table 4). The amount of Ca and Zn in the needles from trees receiving any fertilizer treatment except compost decreased during the growing season both years. Finally, the available nitrate levels in the root ball soils increased during late summer of both years (Table 5). Therefore, despite different weather conditions during both years and the inadequacy of the irrigation system during 2002, the trees responded more or less the same during their first growing season after digging, even though the trees were grown at two different nurseries under different cultural practices.

The strong repeatability of these data during the 2002 and 2003 experiments provides us with the opportunity to draw several conclusions from the studies. First, transplant shock has a strong effect on subsequent growth after digging the trees. Growers may want to use some type of cultural practice in the nursery to reduce the severity of the transplant shock, since even the best fertilizer treatment (compost) failed to increase tree height and trunk diameter growth the first year after digging. The fertilizer treatments did, however, affect foliar nutrition by the end of the first growing season, with compost-treated trees having the highest levels of N, Mg, Ca, S, Mn, and B. The fertilizer spike products used, although different both years of the study, appeared to be good sources of N and S each year. The remaining fertilizer treatments failed to have much effect compared to the pine bark control treatment. Another nutritional aspect to consider is that foliar N levels increased for all trees regardless of the fertilizer treatments used during both years. This result indicates that the two nurseries could apply more N to their Colorado spruce trees. Perhaps adding more N will help the trees to tolerate transplanting better and result in more height and diameter growth the first season after digging. Growers must keep in mind, however, that supplying more N before digging in the nursery could have unintended detrimental results. If trees are to be held in fresh pine bark mulch, then the company holding the plants should plan to apply Ca to the trees since foliar Ca levels decreased noticeably during both years of the study. A final nutritional aspect to consider is that Colorado spruce trees will take up large quantities of Mn if it is available to them. Perhaps supplying Mn to spruce trees held in bark mulch beds will avoid chlorosis or other micronutrient problems.

Maintaining adequate foliar nutrition in the spruce trees is important to help them resume growth after they have overcome transplant shock. Even though the fertilizer treatments failed to influence increases plant height and trunk diameter during the first growing season after digging, specific treatments (compost and to some extent the fertilizer spike) improved foliar nutrition in the needles during this time. Therefore, the compost and fertilizer spike treatments may have their biggest effects during the second growing season after transplanting. The one-year funding limit for research projects makes follow up on this suggestion difficult, but Dr. Lloyd and I have proposed (to the IDA Nursery and Florist Research Committee) a project to study the impact of these fertilizer treatments on spruce tree growth during the second growing season after digging the trees.



### **Significance to the Nursery Industry:**

Specific fertilizer treatments improved foliar nutrition of the newly harvested balled and burlapped Colorado spruce trees during both years of this study. Overall, the compost treatment increased the levels of six (four macro and two micro) nutrients in the needles, with foliar N levels being increased the most of all nutrients. Nitrogen is the element that influences plant growth the most, and so increased foliar N levels should lead to increased growth during the next growing season. The fertilizer spike also helped increase foliar mineral concentration for only N and S but to a lesser extent than the compost treatment. Tree growth, as determined by increases in height and trunk diameter, was unaffected by the fertilizer treatments, probably a consequence of digging and subsequent shock. Although the trees suffered from water stress during 2002, their growth and most aspects of mineral nutrition were similar to those of trees grown under minimal water stress during 2003. Therefore, using compost, such as Eko compost or a compost that has a carbon to nitrogen ratio near 12:1 (nitrogen rich material), mixed with pine bark mulch should provide 5 to 6 foot tall Colorado spruce trees with the necessary nutrients to maintain adequate foliar nutrition while they are being held the first growing season after harvest from the nursery.